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ABSTRACT

This paper describes the results of a three-way evaluation of traditional, televised, and individually-paced instruction in beginning graphics courses. The purpose of the study was to determine mean gain scores for students in each of the three groups. In order to disguise the experiment, no attempt was made to randomly assign subjects to groups, nor were subjects told they were participating in an experiment. Two forms of a standardized test were used in a pretest-posttest format. The mean, standard deviation, scatter diagram, and regression line were calculated for each instructional group and appear in attached appendices. Histograms are used to show pretest and posttest scores for subjects in each of the groups and scatter diagrams are constructed in which lines of regression are drawn. With the use of the standard errors of measurement for each of the instructional groups, it was found that significant achievement resulted for 73 percent of the traditional group, 78 percent of the televised group, and 59 percent of those subjected to individual instruction. Some possible explanations for these phenomena are provided. (Author/CP)

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COLORADO STATE UNIVERSITY

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TITLE OF PAPER Evaluation of Innovative Basic Graphics Instruction

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This paper describes the results of a three-way evaluation of traditional, televised, and individually-paced instruction in beginning graphics courses. The three methods of instruction already existed at West Virginia Institute of Technology and have been in use in the basic graphics courses for several years; therefore the methods, materials, and instructors were seasoned and "debugged" to the point that the faculty of the Graphics and Design department treated both the courses and the methods of instruction as "off-the-shelf" programs which had become more or less standardized through the years. As part of our own concern about student progress and accountability, we undertook the experiment which this paper documents. We did not set out to "prove" any particular method of instruction nor to rank the three methods we were using, but rather simply attempted to determine whether the teaching methods affected student achievement.

The traditional method of instruction met in a lecture-laboratory setting. Both lecture and laboratory were conducted in the same room with no scheduled break between the two functions. The materials used for the lectures consisted of commercially available overhead transparencies and chalkboard drawings for examples of standards, applications, and procedures to be followed in executing assigned problems. Progress through the course was "lock step" in that all tests, quizzes, and other evaluation procedures were conducted for the entire class as a unit.

The televised instruction varied from the traditional method only in presentation form. Extreme reliance was placed on live execution of drawing samples on a drafting table, picked up by an overhead camera and broadcast through video monitors. This method of presentation was augmented by commercially prepared video tapes. Otherwise, the method of instruction was handled exactly the same as the traditional way.

The instructional format of individually-paced instruction was a radical departure from the other two methods. Its basic attributes are:

all formal presentations are accomplished through recorded media - films, slides, tapes, etc.

no attempt is made to make all students study the same topics simultaneously.

all testing and evaluation is done on an individual basis.

There are a number of other details which set this method apart from the others, but these are the fundamental differences. All three methods had text readings and assigned practice problems as common vehicles for instruction.

It was our purpose to discover how these different teaching methods effected student achievement. We did not have a clear cut experiment in that there were undoubtedly some variables over which we could not exercise control such as the possibility of certain types of students all being scheduled into specific sections of the courses based on the availability of differential subjects outside of the department;

such as math, chemistry or English. We did not want a contrived experimental situation to exist in the classes as they were being conducted, so we made no attempt to redistribute the students in different classes but simply we took them as they were, recognizing that such differences in population could exist.

The logical procedure for checking student achievement is through a pretest-posttest format. This method yields information about the students' knowledge prior to taking the prescribed instruction and then gives a comparison with their performance on the same or a similar test at the end of the instructional period. We chose to use this procedure in this experiment.

Since two forms of the standardized test which we chose exist, and we wanted to determine the reliability coefficient between the two, each course section which was selected to be in the experiment was subdivided into four different groups. This allowed administration of the tests in A-B, B-A, A-A, and B-B sequence using either the same or alternate form of the test in a pretest-posttest format with each student. This was done as follows: on the second class meeting of the semester an equal number of the two test forms were shuffled and then distributed to the students in the order in which they were seated (which was by individual selection of the students.) The answer sheets were collected in the order in which the students finished the test and sorted by form for grading. Each subset of answer sheets was then dealt into two classi-

fications and coded to determine which form of the test the individual student would subsequently take as a posttest. This allowed us to take any variations in difficulty of the test form into account in the statistical analysis.

The mean, standard deviation, scatter diagram, and regression line were then calculated and plotted for each of seven distributions: A-B, B-A, A-A, and B-B formats, television instruction, traditional instruction, and individually-paced instruction. Of these, the first four were simply used for standardization purposes and the last three are the comparisons in which we were interested. Additional correlations could have been targetted for analysis such as: individual professor's students, distributions by academic major, by ethnic or economic background, by previous academic achievement, etc., but we chose to limit the investigation to a comparison of the teaching methods only. Additional analysis of the three target distributions was also completed to determine whether any significant differences between pretest and posttest for each situation and among pretests and posttests for all three teaching methods existed.

The instrument we chose to use to gather data for this experiment is the Drawing section of the Cooperative Industrial Arts Tests, published by Educational Testing Service. This test was originally designed as an achievement test for junior high school students, but since its normative data indicates that it is probably a little

difficult for this group and since most of the college bound students in West Virginia receive no training in instrument drawing in the public schools, we felt justified in using it for this experiment. Not of least significance in the decision to use this particular test is the fact that it is the only one in this subject area listed in the Mental Measurements Yearbook. We felt this fact was significant if for no other reason than ease of replication of the experiment by others at their own institutions. As has been stated previously, the test exists in two forms. It is a timed, objective, multiple choice type exam which covers both the theory and application of fundamental engineering drawing. The students had very little difficulty in answering the 50 questions within the 35 minute time limit, so at the college level it could easily be classified as a "power" test, rather than a "speed" test. Its subject matter is fairly comprehensive, but the test does have two distinct drawbacks; 1) its standardization population is not generalizable to college age students and 2) there is a low reliability correlation (.70) between the two forms of the test. Sufficient information is included with the test instructions for individuals to establish normative data for the students at their own institution, but the low correlation between forms must be rectified by other means. As mentioned previously, we chose to combat this problem by organizing the population into subgroups and utilizing all four permutations for the order of administering the forms. This procedure tends to level out any differences between the tests.

All of the students who participated in the experiment were majoring in one of the following academic areas: civil engineering, electrical engineering, chemical engineering, computer sciences, mechanical engineering, industrial arts education, civil engineering technology, drafting and design engineering technology, electrical engineering technology, mechanical engineering technology, or mining engineering technology. With rare exception, they were all first semester freshmen who had graduated from high school two and one-half months prior to the beginning of the experiment. The pretest was administered to the entire enrollment in the fundamental drafting courses, but since natural attrition prevented many of the students from finishing the course, the total population for the experiment was not known until after the posttest had been given. 203 students completed the posttest. They were divided into groups of 72, 65, and 66, for traditional, television, and individually-paced instruction respectively.

The experiment encompassed two multi-section courses in fundamental engineering drawing which had similar sets of objectives. Both courses are concerned with establishing the theory and practice of instrument drawing from the fundamentals of orthographic projection through the execution of completed detail drawings. The main difference in the courses is that of contact hours devoted to laboratory time. Enrollment according to designated major is different for the courses based upon the contact hours, with engineering majors being predominant in the four contact hour course, and engineering technology and industrial arts

majors in the six contact hour course. Neither of the courses is taught exclusively by any single instructor; rather, the course load is spread as evenly as possible among three different instructors. Likewise no instructor used any of the three teaching methods exclusively, but each one used the methods which suited the enrollment and classroom condition. By chance nearly equal populations resulted for the three methodologies.

Tables 1, 2, and 3, (see Appendix) show the histograms of both the pretest and posttest results for the traditional, television, and individually-paced instruction, respectively. Included in these tables are the cumulative totals and percentile rankings for the various test scores. Not shown on these tables, but also of importance statistically, are the percentile ranges which can be assigned to each score based on the standard error of measurement of the test. According to Educational Testing Service, the standard error of measurement of both forms of the test is a constant 3 raw score points. The percentile range which can be assigned to each score is determined by using the percentile associated with the raw scores which are three above and three below the score in question. For example the percentile range for the raw score of 17 in the pretest under traditional instruction is from the percentile for a raw score of 14 to the percentile for a raw score of 20 or from 6 to 25. The standard error of measurement also must be used in determining significance as will be discussed later.

Figures 1, 2, and 3 show graphical comparisons of the pretest and posttest distributions for the traditional, televised, and individually-paced instruction methods, respectively. One thing which is easily discernable from either the histograms or the distributions of the data is that regardless of the method of instruction the students appear to have learned a considerable amount as evidenced by the shift of the distributions and the differences of means.

Figures 4 and 5 show composite graphs comparing all three pretests and all three posttests, respectively. A test of significance on the variation of the means indicates in the pretest there is no significant difference in the populations. However, in the posttest, traditional instruction was found to be significantly better, individually-paced instruction was significantly worse and television instruction remained unchanged. Analysis of the variance of the standard deviations indicate that both the traditional and individually-paced instruction groups are also significantly more uniform in posttest results than is the television instruction group.

Of greatest significance in analysing the data we compiled is a scatter diagram. Figures 6, 7, and 8 and Tables 4, 5, and 6 show the scatter diagrams and associated data for traditional, televised and individually-paced instruction respectively.

Each of the scatter diagrams is a plot of paired scores for the

pretest (abscissa) and posttest (ordinate.) Results of the entire population in each of the three groups has been plotted. The solid diagonal line running from the origin toward the upper right hand corner represents the status quo condition--the student scored identically on both tests. The standard error of measurement lets us establish an envelope or range of scores which could be considered status quo due to the possible variation of three raw score points which could be expected by any student taking an immediate retest in either the pretest or posttest situations. This envelope or range is denoted by the dashed lines above and below the status quo line.

From this plot it is relatively easy to determine what percentage of the students scored significantly higher or lower on the posttest compared with the pretest. All three populations had approximately 1.5% who scored significantly lower on the posttest. Significantly higher results were 73% for traditional, 78% for televised, and 59% for individually-paced instruction. The number of students whose scores appear in the upper end of the status quo envelope are to be expected. They are the individuals who have had extensive training in the subject area prior to enrolling in the course. The individuals in the lower end of the envelope are not as easily categorized. These may be individuals who lack motivation, who learn to respond to specifics rather than generalizations, who have language and reading skills problems, or otherwise manifest problems as students. An effort must be made to identify these students and to deal with their problems if you wish to

retain them in your program.

Also plotted on the scatter diagram are the values of the mean for the pretest and posttest and the calculated regression line which could be used for predicting results on the posttest when only the pretest score is known, but which we are using as a comparison indicator between populations. The data in each accompanying table gives all the numerical information necessary to plot the scatter diagram itself.

Comparison of the results yields some very interesting conclusions. As has already been stated, the distributions appear to have no significant differences between them prior to instruction. All three groups of students fared significantly better on the posttest, but the traditional instruction method appeared to do better on the average than either of the other groups, and the individually-paced group fared significantly worse. And, an analysis of the variance of the standard deviations indicates that both the traditional and individually-paced instruction groups are also significantly more uniform in posttest results than is the television instruction group.

Does this mean that the traditional method of instruction is inherently better than individually-paced instruction? It does not. Examination of the two scatter diagrams indicates that different subgroups within each of the two populations ended up being in the status

que envelope. For the traditional instruction method, it was a group which scored lower on the pretest while for the individually-paced instruction group it consisted of students who scored higher on the pretest. Students who knew little about the subject fared well under individually-paced instruction but did not do as well under traditional instruction. This is probably the result of having to pace the traditional course at a faster rate than these individuals can work to assimilate the knowledge. On the other hand, students with prior knowledge of the subject apparently tend to extend their knowledge under traditional instruction, but loaf under individually-paced instruction. This would indicate that performance on the pretest could be used to differentially place students in a course offered by either of the two methods. The testing of such an hypothesis will hopefully be the subject of an additional paper on this topic to be published in the near future.

What about television instruction? The fact that there is a wider spread to the data, as shown both by the value of the standard deviation and the slope of the regression line, indicates that television should not be an exclusive or habitual teaching medium in this subject. The criticism that has been levelled at "Sesame Street" and "The Electric Company" appears to be applicable here as well. "The rich get richer, and the poor can't keep up." Television is a transient medium. It does not lend itself easily, as used in this experiment, to review and sequence reinforcement. We are certain that there

must be other data available which supports the extensive use of television. If so, we would welcome seeing the results of experimentation, using the same standardized exam, which would prove us wrong.

APPENDIX

TABLE 1
HISTOGRAM & PERCENTILES OF TRADITIONAL INSTRUCTION

	PRETEST				POSTTEST			
Score	Tally	Freq.	Cum. Freq.	%ile Rank	Tally	Freq.	Cum. Freq.	%ile Rank
50								
49								
48	/	1	72	99				
47		0	71	99	//	2	72	99
46	/	1	71	98	//	2	70	98
45		0	70	97	/	1	68	95
44		0	70	97	////	4	67	93
43		0	70	97	///	3	63	90
42		0	70	97	////	4	60	85
41	//	2	70	97	𝍸 /	6	56	80
40	/	1	68	95	𝍸 ///	8	50	73
39		0	67	94	//	2	42	63
38	//	2	67	93	///	3	40	57
37	/	1	65	91	𝍸	5	37	53
36	///	3	64	89	///	3	32	48
35	//	2	61	86	///	3	29	42
34	//	2	59	83	/	1	26	38
33	/	1	57	80	///	3	25	35
32		0	56	78	////	4	22	32
31	//	2	56	77	//	2	18	27
30	//	2	54	76	/	1	16	23
29	////	4	52	73	/	1	15	21
28	//	2	48	69	/	1	14	20
27	////	4	46	65	///	3	13	18
26	𝍸 //	7	42	61	/	1	10	16
25	////	4	35	53	//	2	9	13
24	////	4	31	45		0	7	11
23	𝍸 /	6	27	40	////	4	7	9
22	//	2	21	33	//	2	3	7
21	//	2	19	27		0	1	2
20	////	4	17	25	/	1	1	1
19	////	4	13	20				
18	//	2	9	15				
17	/	1	7	11				
16		0	6	9				
15	///	3	6	8				
14		0	3	6				
13		0	3	4				
12		0	3	4				
11	//	2	3	4				
10		0	1	2				
9	/	1	1	1				

n=72

TABLE 2
HISTOGRAM & PERCENTILES OF TELEVISION INSTRUCTION

	PRETEST				POSTTEST			
Score	Tally	Freq.	Cum. Freq.	%ile Rank	Tally	Freq.	Cum. Freq.	%ile Rank
50								
49								
48								
47					//	2	65	99
46					//	2	63	98
45					/	1	61	95
44						0	60	93
43	/	1	65	99	卌	5	60	92
42		0	64	99	////	4	55	88
41	//	2	64	98	/	1	51	81
40		0	62	96	///	3	50	77
39		0	62	95	卌	5	47	74
38		0	62	95	卌	5	42	68
37		0	62	95	卌	5	37	60
36	/	1	62	95	//	2	32	53
35	//	2	61	94	///	3	30	47
34	//	2	59	92	///	3	27	43
33	////	4	57	89	卌	5	24	39
32	///	3	53	84	卌	5	19	33
31	/	1	50	79	//	2	14	25
30	///	3	49	76	/	1	12	20
29	///	3	46	73	///	3	11	17
28	卌	5	43	68	//	2	8	15
27		0	38	62	//	2	6	10
26	//	2	38	58		0	4	7
25	////	4	36	56		0	4	6
24	卌//	7	32	52		0	4	6
23	卌//	7	25	43	/	1	4	6
22	//	2	18	33		0	3	5
21	////	4	16	26	/	1	3	5
20	///	3	12	21		0	2	4
19	/	1	9	16		0	2	3
18	/	1	8	13		0	2	3
17	/	1	7	11		0	2	3
16	//	2	6	10		0	2	3
15	//	2	4	7		0	2	3
14		0	2	4	/	1	2	3
13		0	2	2		0	1	2
12	/	1	2	2		0	1	1
11		0	1	2		0	1	1
10		0	1	1	/	1	1	1
9		0	1	1				
8	/	1	1	1				

n=65

TABLE 3
HISTOGRAM & PERCENTILES OF INDIVIDUALLY-PACED INSTRUCTION

	PRETEST				POSTTEST			
Score	Tally	Freq.	Cum. Freq.	%ile Rank	Tally	Freq.	Cum. Freq.	%ile Rank
50								
49								
48								
47								
46					/	1	66	99
45					//	2	65	99
44					///	3	63	97
43						0	60	93
42					///	3	60	91
41					/	1	57	88
40	𝍸	5	66	99	///	3	56	85
39		0	61	96		0	53	82
38	/	1	61	92		0	53	80
37	//	2	60	91	///	3	53	80
36	/	1	58	89	𝍸	5	50	78
35		0	57	87	𝍸/	6	45	72
34	//	2	57	86	𝍸/	6	39	63
33	///	3	55	84	𝍸	5	33	54
32	𝍸	5	52	81	///	3	28	46
31		0	47	75	𝍸/	6	25	40
30	///	3	47	71	𝍸	5	19	33
29	/	1	44	69	////	4	14	25
28	////	4	43	66	/	1	10	18
27	/////	4	39	59	/	1	9	14
26		0	35	56		0	8	13
25	/////	4	35	53	//	2	8	12
24	/	1	31	50	///	3	6	10
23		0	30	46	/	1	3	7
22	////	4	30	45		0	2	4
21	𝍸	5	26	42	/	1	2	3
20	𝍸//	7	21	35		0	1	2
19	/	1	14	26		0	1	1
18	////	4	13	20		0	1	1
17	/	1	9	16	/	1	1	1
16		0	8	13				
15	///	3	8	12				
14	/	1	5	10				
13	/	1	4	6				
12	///	3	3	5				

n=66

FIGURE 1
DISTRIBUTION OF TRADITIONAL INSTRUCTION
— PRETEST RESULTS
--- POSTEST RESULTS

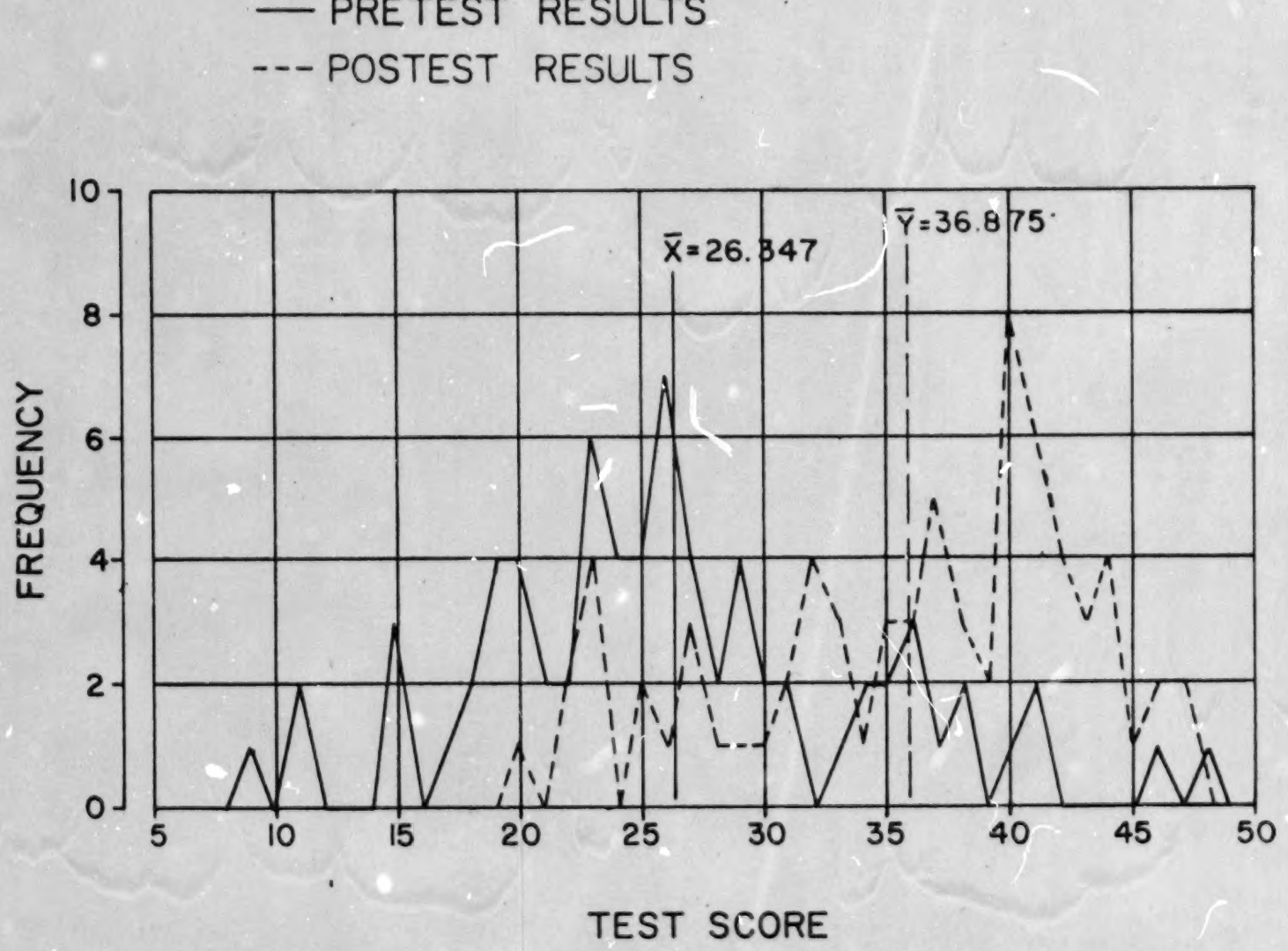


FIGURE 2
DISTRIBUTION OF T.V. INSTRUCTION
—— PRETEST RESULTS
---POSTEST RESULTS

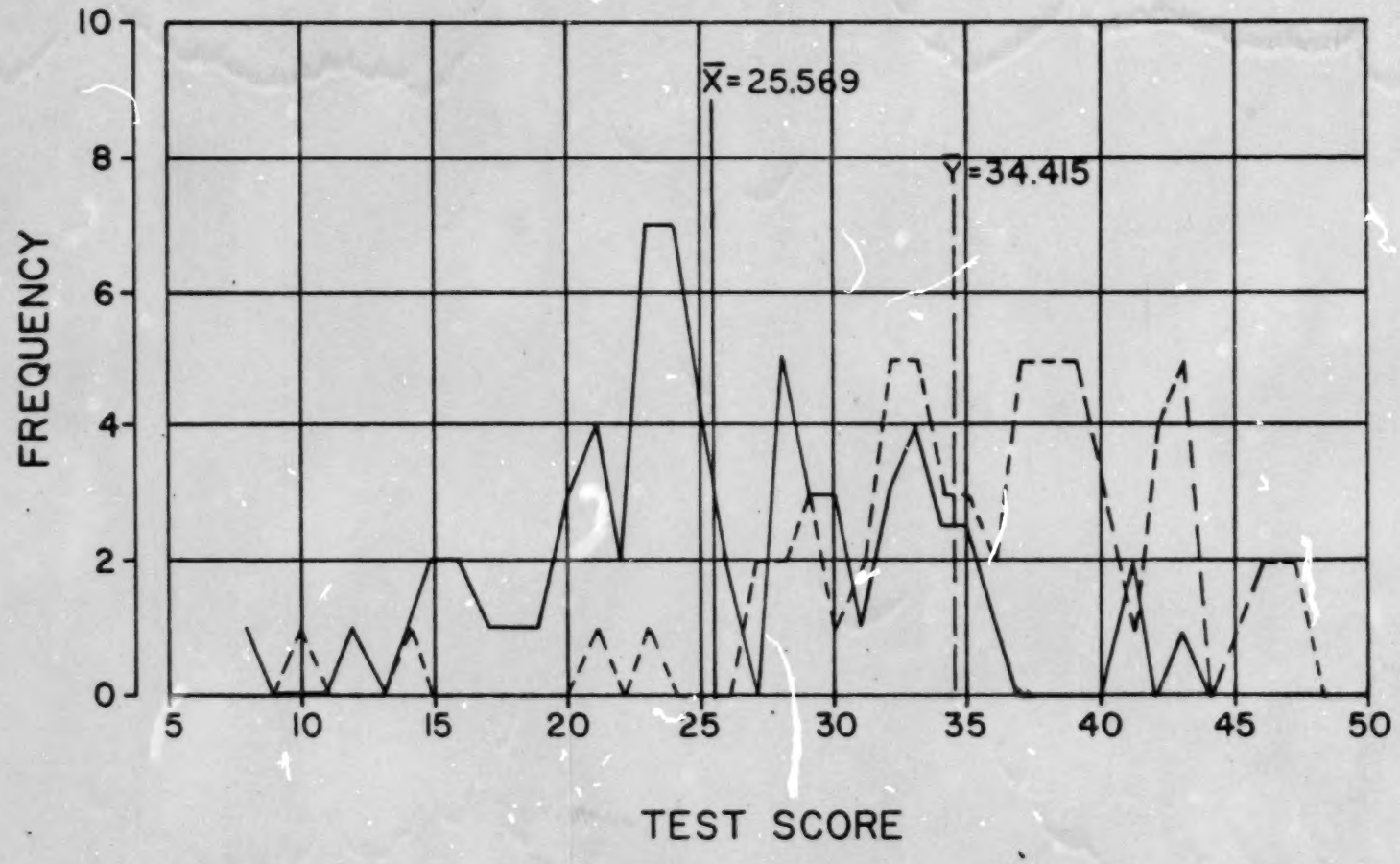


FIGURE 3
DISTRIBUTION OF I.P.I. INSTRUCTION
—— PRETEST RESULTS
---POSTEST RESULTS

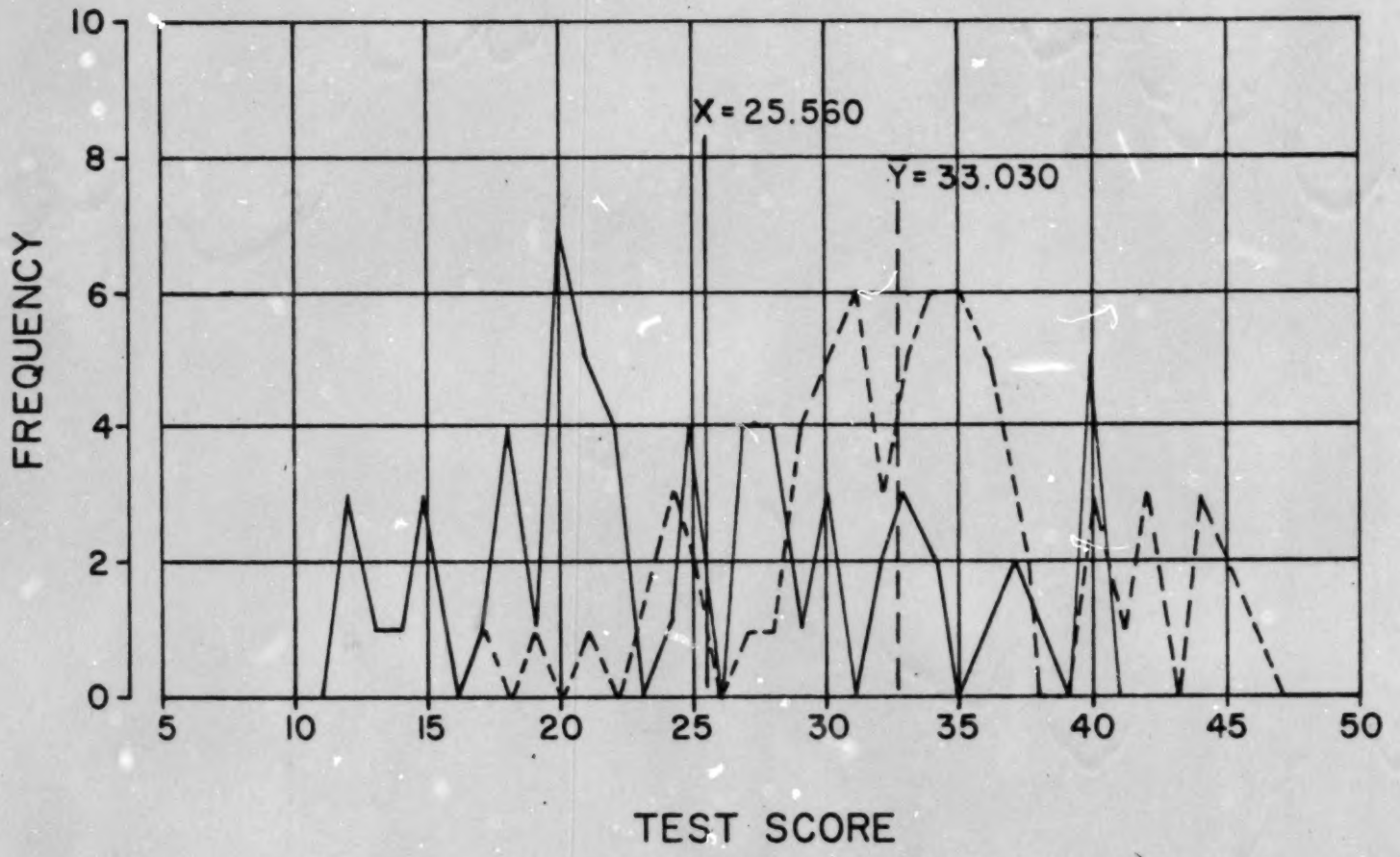


FIGURE 4

COMPOSITE COMPARISON OF PRETEST RESULTS

—— TRADITIONAL INSTRUCTION

--- TELEVISION INSTRUCTION

-·-·- INDIVIDUALLY PACED INSTRUCTION

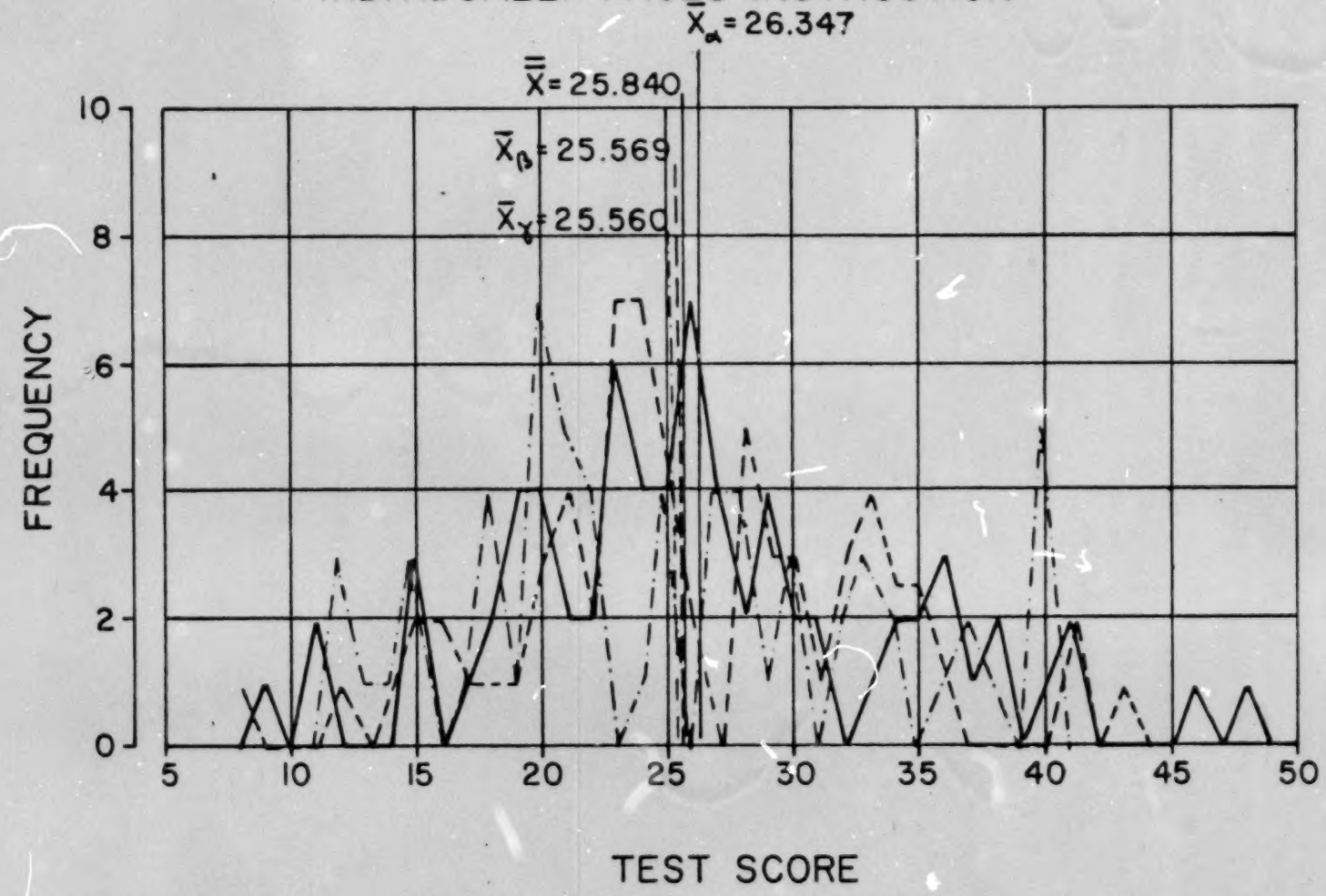


FIGURE 5

COMPOSITE COMPARISON OF POSTEST RESULTS

—— TRADITIONAL INSTRUCTION

- - - TELEVISION INSTRUCTION

-·-·- INDIVIDUALLY PACED INSTRUCTION

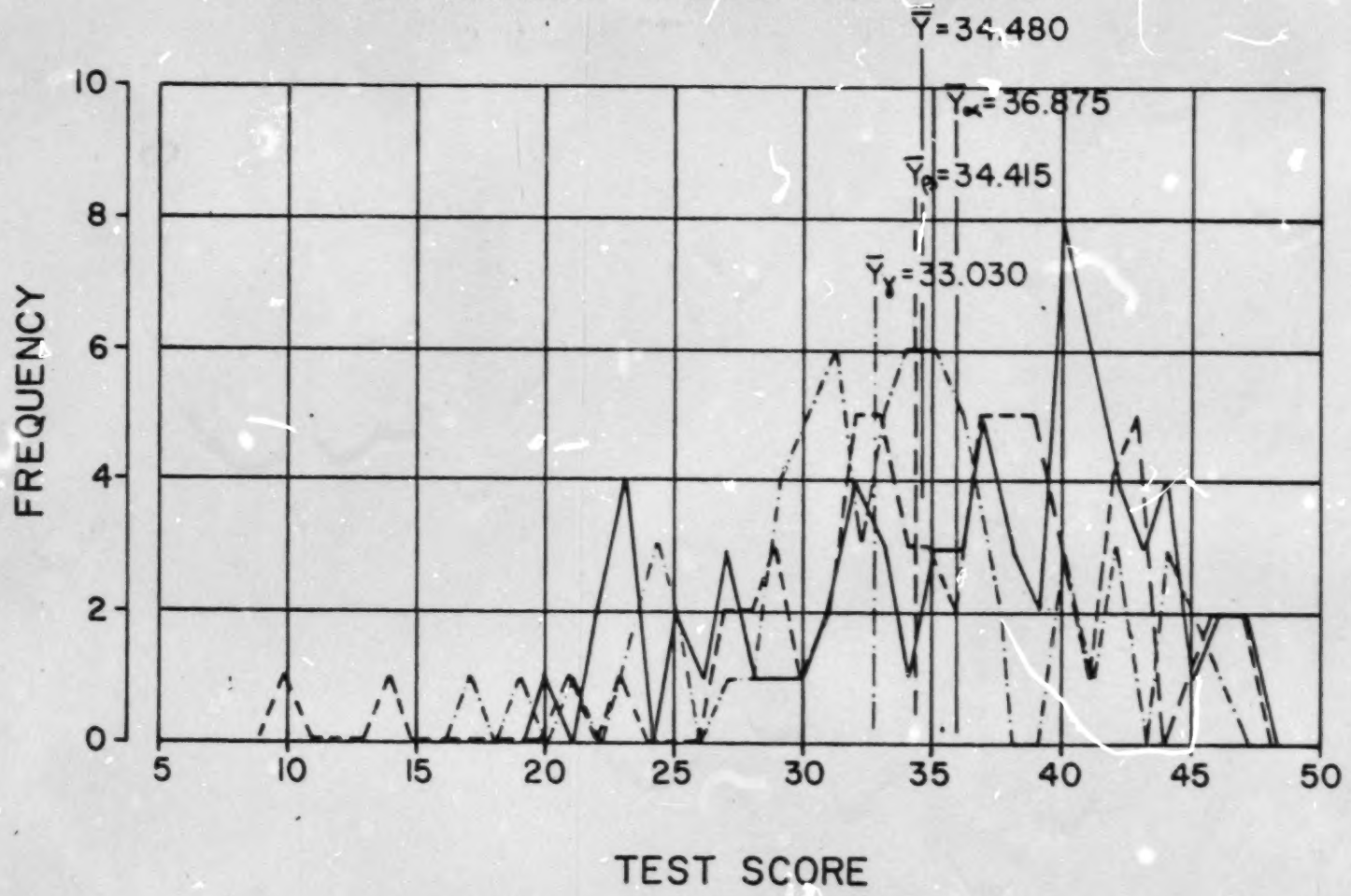
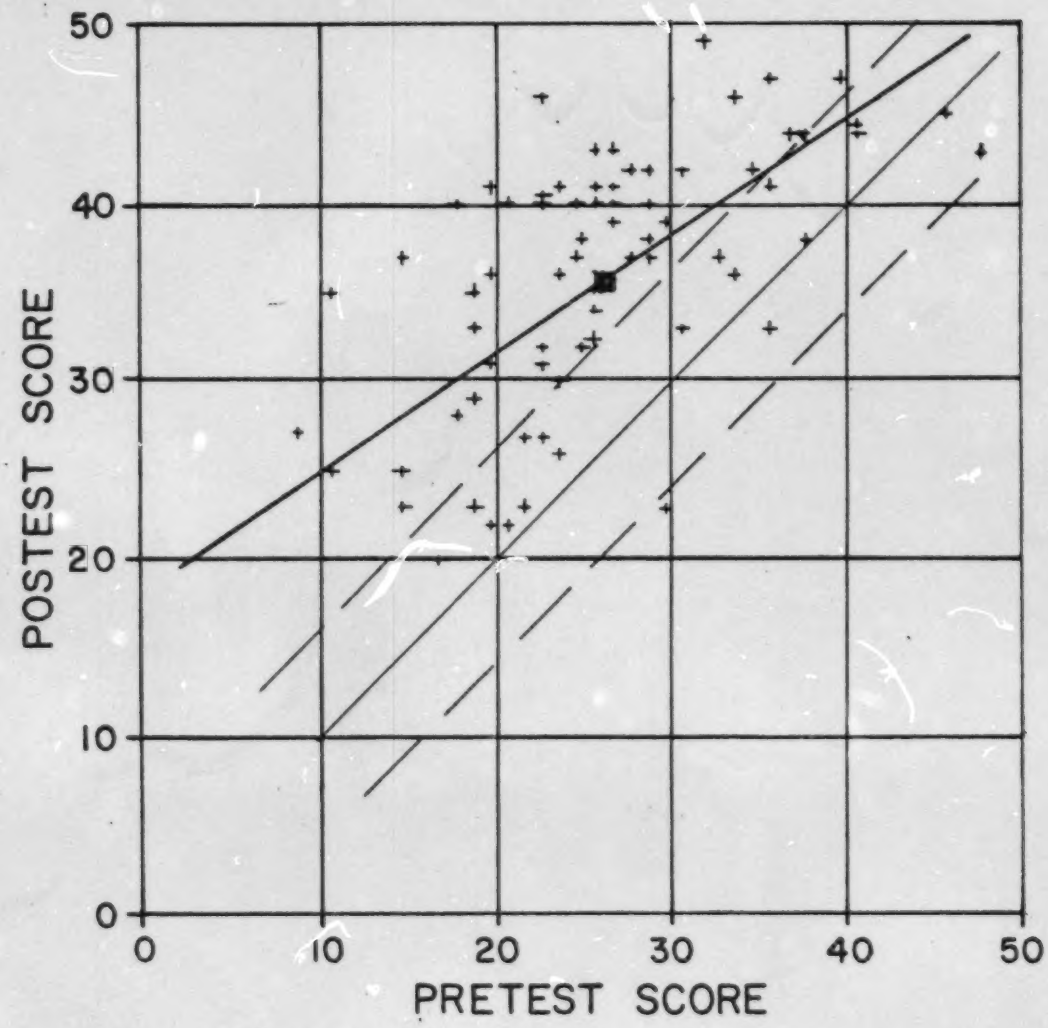


FIGURE 6
SCATTER DIAGRAM AND REGRESSION LINE
OF TRADITIONAL INSTRUCTION



A-9

FIGURE 7
SCATTER DIAGRAM AND REGRESSION LINE
OF TELEVISION INSTRUCTION

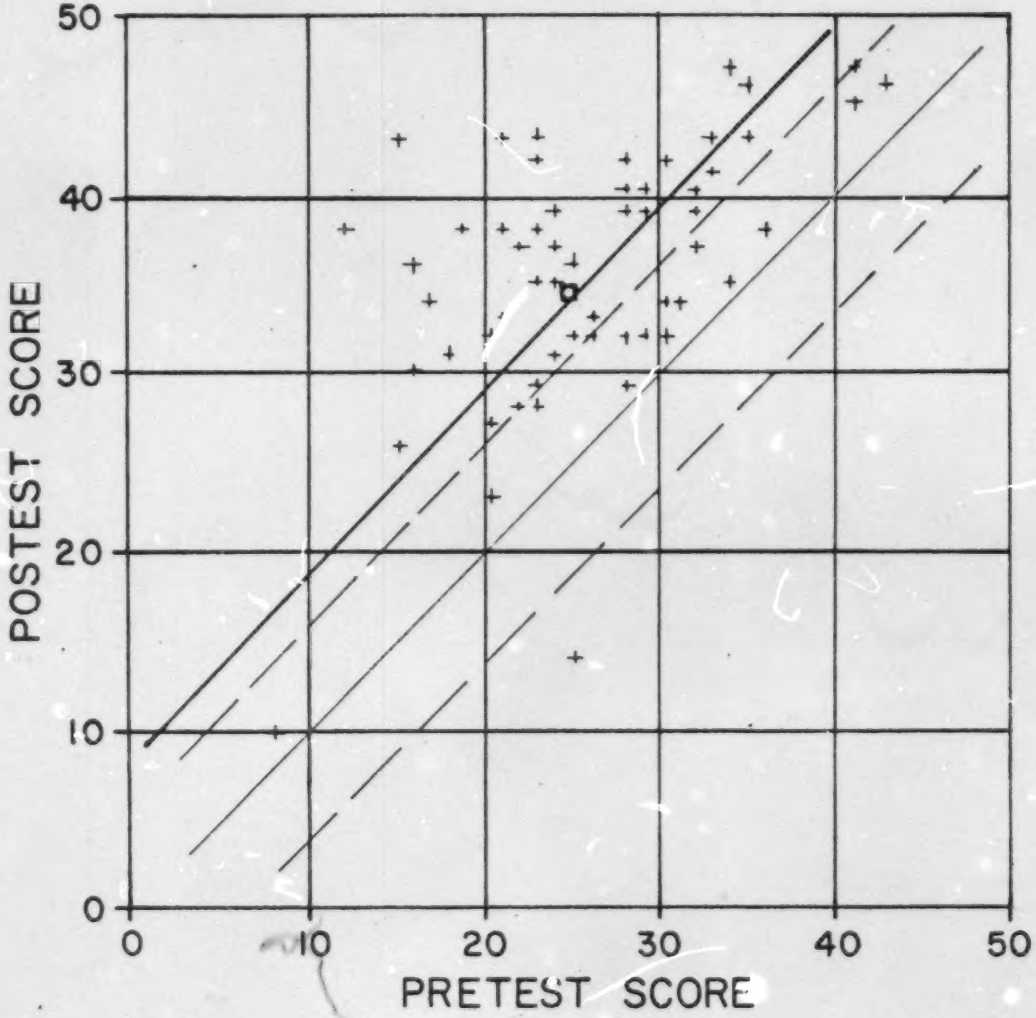
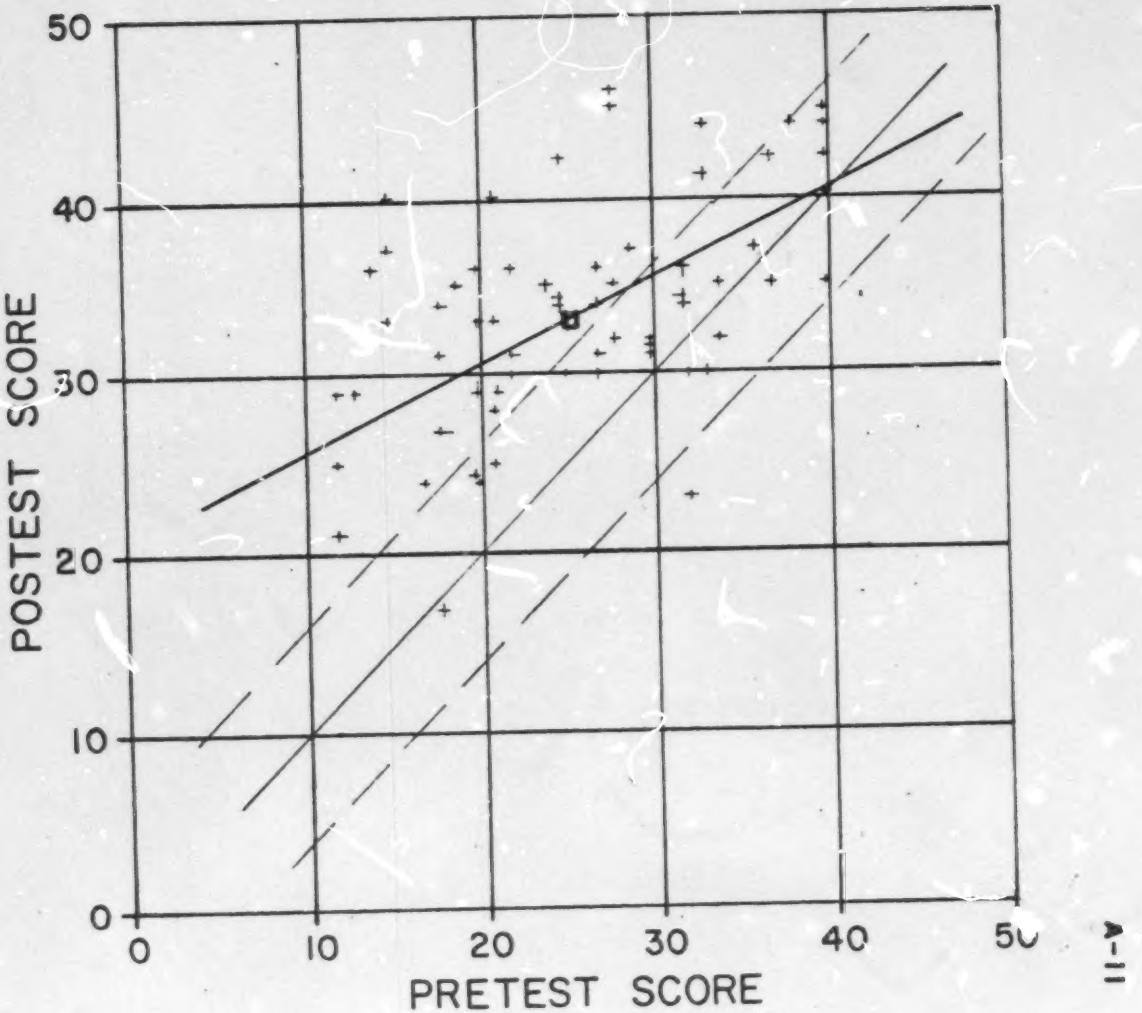


FIGURE 8
SCATTER DIAGRAM AND REGRESSION LINE
OF INDIVIDUALLY PACED INSTRUCTION



FORMULAS FOR CALCULATING QUANTITATIVE INFORMATION

$$\sigma = \sqrt{\frac{\sum (X^2) - \frac{(\sum X)^2}{N}}{N}}$$ STANDARD DEVIATION

$$b = \frac{\sum_{i=1}^{N} X_i Y_i - N\bar{X}\bar{Y}}{\sum_{i=1}^{N} X_i^2 - N\bar{X}^2}$$ SLOPE OF REGRESSION LINE

$Y = a + bX$ STRAIGHT LINE EQUATION

$S = \sigma^2$ VARIANCE

TABLE 4

QUANTITATIVE INFORMATION

FOR TRADITIONAL INSTRUCTION

N = 72

PRETEST	POSTEST
$\Sigma X = 1897$	$\Sigma Y = 2583$
$\overline{X} = 26.347$	$\overline{Y} = 35.875$
$\Sigma(X^2) = 54,487$	$\Sigma(Y^2) = 96,283$
$(\Sigma X)^2 = 3,598,609$	$(\Sigma Y)^2 = 6,671,889$
$\sigma = 7.9$	$\sigma = 7.05$
$S = 62.41$	$S = 49.70$

+SIGNIFICANT DIFFERENCE (%) $= \frac{53}{72} = 73\%$

−SIGNIFICANT DIFFERENCE (%) $= \frac{1}{72} = 1.4\%$

$\Sigma XY = 65,229$

$b = 0.5929$

$0.3835 \leqslant b \leqslant 0.8023$ (TEST OF SIGNIFICANCE)

TABLE 5

QUANTITATIVE INFORMATION

FOR TELEVISION INSTRUCTION

N = 65

PRETEST	POSTEST
$\Sigma X = 1680$	$\Sigma Y = 2237$
$\bar{X} = 25.846$	$\bar{Y} = 34.415$
$\Sigma (X^2) = 46,464$	$\Sigma (Y^2) = 85,299$
$(\Sigma X)^2 = 2,822,400$	$(\Sigma Y)^2 = 5,004,169$
$\sigma = 6.841$	$\sigma = 11.308$
$S = 46.807$	$S = 127.870$

+ SIGNIFICANT DIFFERENCE (%) $= \frac{51}{65} = 78\%$

− SIGNIFICANT DIFFERENCE (%) $= \frac{1}{65}$ 1.5%

$\Sigma XY = 61,500$

$b = 1.0841$

$0.9400 < b < 1.2280$ (TEST OF SIGNIFICANCE)

TABLE 6
QUANTITATIVE INFORMATION
FOR INDIVIDUALLY PACED INSTRUCTION
N=66

PRETEST	POSTEST
$\Sigma X = 1687$	$\Sigma Y = 2180$
$\bar{X} = 25.560$	$\bar{Y} = 33.030$
$\Sigma (X^2) = 47,205$	$\Sigma (Y^2) = 76,517$
$(\Sigma X)^2 = 2,845,969$	$(\Sigma Y)^2 = 4,752,400$
$\sigma = 7.800$	$\sigma = 8.260$
$S = 60.840$	$S = 68.227$

+SIGNIFICANT DIFFERENCE (%) $= \frac{39}{66} = 59\%$

−SIGNIFICANT DIFFERENCE (%) $= \frac{1}{65}$ 1.5%

$\Sigma XY = 57,743$

$b = 0.4949$

$0.3603 \leq b \leq 0.6294$ (TEST OF SIGNIFICANCE)